PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 :
H01B 7/34, H05K 9/00
D03D 15/00, D04B 1/00
D04C 1/00, D04H 1/00

A1

(11) International Publication Number: WO 86/ 03050

(43) International Publication Date: 22 May 1986 (22.05.86)

(21) International Application Number: PCT/US85/02245

(22) International Filing Date: 12 November 1985 (12.11.85)

(31) Priority Application Numbers: 670,698
735,883

(32) Priority Dates: 13 November 1984 (13.11.84)
17 May 1985 (17.05.85)

(33) Priority Country: US

(71) Applicant: RAYCHEM CORPORATION [US/US]; 300 Constitution Drive, Menlo Park, CA 94025 (US).

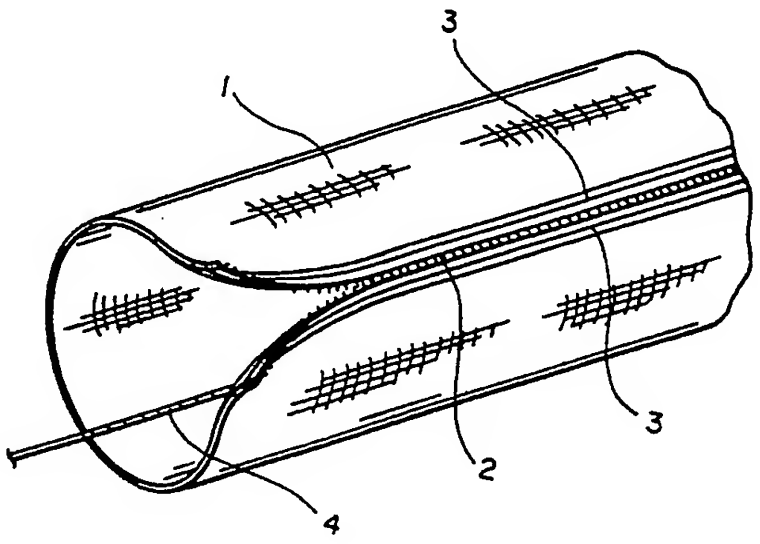
(72) Inventors: GLADFELTER, Harry, F. ; 219 Beacon Drive, Phoenixville, PA 19460 (US). CONAGHAN, Thomas, B. ; 22 S. Main Street, Rock Hall, MD 21661 (US).

(74) Agent: DILLAHUNTY, Gene, T.; Raychem Corporation, 300 Constitution Drive, Menlo Park, CA 94025 (US).

(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), NL (European patent), SE (European patent).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: SHIELDING FABRIC AND ARTICLE



(57) Abstract

A fabric for RFI/EMI shielding, a substrate shielded by the fabric and methods of making wherein the fabric (1) is woven, braided or wrap knitted from yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise from about 15% to about 80% by weight of the fabric. Further provided (10) is a wraparound tubular article for EMI/RFI shielding of electrical conductors and cables and methods of making which comprises a fabric sheet (1) and zipper closure (2) which are nonconductive materials which have been coated or plated with a conductive metal to provide electrical shielding which is of substantially uniform effectiveness around the circumference of the wraparound tubular article when the zipper closure is closed.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BG	Bulgaria
BR	Brazil
CF	Central African Republic
CG	Congo
CH	Switzerland
CM	Cameroon
DE	Germany, Federal Republic of
DK	Denmark
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
HU	Hungary
IT	Italy
JP	Japan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
MC	Monaco
MG	Madagascar
ML	Mali
MR	Mauritania
MW	Malawi
NL	Netherlands
NO	Norway
RO	Romania
SD	Sudan
SE	Sweden
SN	Senegal
SU	Soviet Union
TD	Chad
TG	Togo
US	United States of America

SHIELDING FABRIC AND ARTICLE

Field of the Invention

This invention relates to shielding of electrical conductors or other substrates from electromagnetic interference (EMI) and radio frequency interference (RFI) by providing a fabric which has effective shielding properties and providing a wraparound tubular article which has effective shielding properties.

Background of the Invention

RFI/EMI shielding of electrical conductors, cables and other components have conventionally been provided by wire overbraid, metal foils, metalized fabrics, and the like. Typical of such shielding are U.S. patents 3,946,143 and 4,016,356 to McLaughlin; 3,423,515 to Eichberg; and 3,089,915, 3,582,532 and 4,409,427 to Plummer. The disclosures of the above patents are incorporated herein by reference.

The metalized fabrics referred to in the '427 Plummer patent are typically made by electroless plating or coating of plastic or non-conductive fibers as exemplified by U.S. patents 3,733,213 to Jacob; 3,877,965 to Broadbent et al.; and 4,247,596 to Yee, the disclosures of which are incorporated herein by reference. The conductive fibers of Broadbent et al. and others have been used in very low proportions such as from 0.005% to 10% by weight in various fabrics such as carpets to help prevent static electricity build up.

Brief Description of the Drawings

Figure 1 is an illustration of a preferred article according to this invention, which is a wraparound tubular article.

Figure 2 shows in graphic form the shielding effectiveness of a tubular article according to this invention as set forth in Example 1.

Figure 3 shows in graphic form the shielding effectiveness of a tubular article according to this invention as set forth in Example 2.

Figure 4 shows in graphic form the shielding effectiveness of a tubular article according to this invention as set forth in Example 3.

Figure 5 shows in graphic form the shielding effectiveness of a tubular article according to this invention as set forth in Example 4.

Figure 6 shows in graphic form the shielding effectiveness of a wraparound tubular article according to this invention as set forth in Example 5.

Figure 7 shows in graphic form the shielding effectiveness of a wraparound article according to this invention as set forth in Example 6.

Description of the Invention

In one aspect invention provides a wraparound tubular article for enclosing and electrically shielding electrical conductors and cables comprising a nonconductive woven, braided, or warp knitted fabric sheet having two opposing edges and a nonconductive zipper closure attached to said opposing edges and adapted for holding the woven fabric sheet in a tubular configuration around an electrical conductor or cable wherein the woven fabric and zipper closure are coated or plated with a conductive metal to thereby provide electrical shielding which is of substantially uniform effectiveness around the circumference of the wraparound tubular article when the zipper closure is closed.

In another aspect, this invention provides a fabric for electrical shielding which comprises a fabric which is woven, braided or warp knitted from a yarn which comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric.

In another aspect, this invention provides a fabric for electrical shielding which is woven and comprises:

warp yarns which comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are

plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the warp yarns; and

filling yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 1% and about 20% by weight of the filling yarns.

In another aspect, this invention provides an article for electrical shielding wherein the article is formed at least in part from a fabric which is woven, braided or warp knitted from a yarn which comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric.

In another aspect, this invention provides an assembly comprising a substrate and a fabric in shielding relationship therewith wherein the fabric is woven, braided or warp knitted from yarns which comprise conductive and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the con-

ductive fibers comprise between about 15% and about 80% by weight of the fabric.

In another aspect, this invention provides a method of making fabric for electrical shielding which comprises weaving, braiding or warp knitting yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric.

In another aspect, this invention provides a method of electrically shielding a substrate which comprises placing in shielding relationship with the substrate a fabric which is woven, braided or warp knitted from yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric.

In another aspect this invention provides methods of making a wraparound tubular article having a zipper closure wherein the zipper closure and the fabric are coated or plated with a conductive metal. One method of making said article comprises weaving, braiding, or warp knitting a fabric sheet from a fiber which is coated or plated with a conductive metal and attaching to opposing edges of the fabric sheet a zipper closure which has been plated or

coated with a conductive metal such that the fabric sheet and the zipper closure provide electrical shielding which is of substantially uniform effectiveness around the circumference of the tubular article when the zipper closure is closed. Another method of forming the wraparound tubular article of this invention comprises coating or plating a woven, braided, or warp knitted fabric sheet of nonconductive fiber with a conductive metal and attaching to the opposing edges of the coated or plated fabric sheet a zipper closure which has been coated or plated with a conductive metal to thereby provide electrical shielding which is of substantially uniform effectiveness around the circumference of the wraparound tubular article when the zipper closure is closed. A preferred method of making the wraparound tubular article described above comprises attaching a zipper closure to opposing edges of a woven, braided, or warp knitted fabric sheet and plating or coating the assembled fabric sheet/zipper closure article with a conductive metal to thereby provide electrical shielding which is of substantially uniform effectiveness around the circumference of the wraparound tubular article when the zipper closure is closed.

The non-conductive fibers useful in this invention include any non-conductive natural or synthetic fibers such as cotton, wool, silk, cellulose, polyester, polyamide, nylon, and the like. The conductive fibers useful in this invention include conductive fibers made from carbon, graphite or a conductive polymer or non-conductive fibers which can be plated, coated or impregnated with a conductive material and be able to retain that material for the length of time and under service conditions to be encoun-

tered by the shielding fabric. Depending on the durability, end use and other desirable properties for the shielding article made from the fabric, any combination of conductive and non-conductive fibers may be used. The conductive material plated, coated or impregnated on or in the fiber may be a metal, carbon, and the like. Some preferred conductive fibers include nylon plated with silver or copper, and polyester plated with silver, copper, nickel or tin.

The fabrics provided by this invention are made from yarns which comprise a blend of conductive and non-conductive fibers of the above mentioned types wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric. Preferably, the fabric should comprise between about 15% and about 70% by weight conductive fibers and most preferably between about 20% and about 60%. The yarns useful in this invention comprise a blend of conductive and non-conductive fibers wherein the conductive fibers comprise between about 20% and about 80% by weight of the yarn, except where the yarn is a second yarn in the fabric, such as the filling, the yarn may comprise as low as about 1% by weight conductive fiber. Preferably the yarn should comprise between about 30% and about 70% by weight conductive fibers and more preferably between about 35% and about 65%. Preferably a second yarn in the fabric, such as a filling yarn, should comprise between about 1% and about 20% by weight conductive fibers and more preferably between about 3% and about 15%.

The articles formed from the fabrics according to this invention will depend on the electrical device or other substrate to be shielded. For example, sheets of fabric

may be used to shield cabinets for electronic equipment, electric terminals and connectors, while tubular shapes will be used to shield conductors and cables, including round or flat, ribbon cables. Various shapes may be made to shield other components.

It is also useful to include in the fabric of this invention a drainwire or ground wire. The drainwire is conveniently incorporated as a warp strand in a woven fabric. More than one drainwire can be used depending on the desired grounding con-figuration and the shielding effectiveness required. In general one to four drainwires in the warp direction in a tubular article are sufficient. The drainwire may be stranded copper, tinned or silvered copper, or other material useful as a flexible ground wire.

Tubular articles according to this invention may be made in a wraparound configuration. Closure may be by overlapping the fabric and held in place by any suitable means. A preferred means of closure for a wraparound tubular article according to this invention is a non-conductive zipper which has been coated or plated with a conductive metal and bonded or fused to the edges of the fabric forming the wraparound. In this respect, the fabric used with a plated non-conductive zipper can contain 100% conductive fibers or yarns. Hook and loop closures coated with metal may be used as the closure means, e.g., the VELCRO and HI-MEG products available from Velcro USA, Inc.

The fabric sheet may be woven, braided, or warp knitted. When a warp knitted fabric is used, the wales must run longitudinally the length of the wraparound tubu-

lar article. Braided or warp knitted fabrics may be tubular which are then split when the zipper closure is attached. The braided or warp knitted fabric may be a flat sheet to which the zipper closure is attached to opposing edges.

The preferred fabric for the article of this invention is a woven fabric wherein the warp strands are longitudinal along the length of the wraparound tubular article and the filling runs across the fabric and consequently around the circumference of the wraparound tubular article when the zipper closure is closed. It is believed that warp strands along the length of the wraparound tubular article provide the most direct and straight path to grounding. While the braided and warp knitted fabrics can provide a relatively direct path to grounding, the woven fabric is preferred.

The zipper closure may be any conventional interlocking slide fastener with sufficient tape on the edges thereof for uniformly effective attachment to the edges of the fabric sheet. The interlocking elements of the zipper may be spirals or other type of interlocking elements. The zipper closure may be the conventional visible type closure or may be a concealed type zipper that is not visible from the outside of the wraparound tubular article when the zipper is closed. The tubular article of this invention may be supplied in a continuous roll which is cut to any desired length and closed around the cable or cable bundle with a separate slider tool such as those known in the art and illustrated in U.S. patents 1,452,372 to Gomez or 4,027,369 to Kando et al.

The materials used for the fabric sheet and for the zipper closure are nonconductive materials, such as various plastics. While not necessary, it is preferred in general that the fabric sheet and the zipper material be the same in order to provide enhanced uniform shielding characteristics. The fabric sheet and the zipper closure may be made of nylon, polyester and similar synthetic or plastic materials. These materials can be used for the fabric sheet, the tape edges of the zipper closure and the teeth or interlocking elements of the zipper closure such that the entire wraparound tubular article of this invention would be of one uniform material, such as polyester or nylon. The preferred material for the fabric sheet, the zipper tape and the zipper interlocking elements is nylon.

The selection of the nonconductive fabric and zipper materials and the conductive metal coating or plating will depend on the shielding and other physical properties desired. The conductive metal used may be a combination of metals and will be selected according to its ability to plate or coat the fabric/zipper material and according to the shielding effectiveness on that material. The yarns in the fabric may be multifilament or monofilament. The texture of the weave, braid or warp knit can vary depending on the material used, the metal used and the frequencies at which the shielding is desired.

It has been found that the amount of conductive metal plated or coated on the fabric and zipper directly affects the shielding effectiveness. The amount of metal used will depend on the material of the fabric and zipper, the texture of the fabric, the type of zipper and the frequencies

at which the shielding is desired. The amount of metal used will also depend on the shielding effectiveness desired, the conductivity of the metal as well as the cost of the metal. In general, the amount of metal should be at least about 8% by weight based on the total weight of the metal plated or coated fabric/zipper article. Maximum effectiveness in shielding is generally provided at about 16%. As shown in the Examples below, silver on nylon is effective at the frequencies shown in the Figures at about 10% to 13%.

The conductive metal coating or plating applied to the fabric sheet and the zipper closure may be silver, copper, nickel, and the like and the methods of plating or coating the conductive metal on the fabric sheet and the zipper closure may be any suitable method known in the art. Such methods of plating or coating are illustrated by U.S. patents 3,733,213 to Jacob, 3,877,965 to Broadbent et al. and 4,247,596 to Yee, the disclosures of which are incorporated herein by reference. The method of plating or coating the conductive metal on the fabric sheet and the zipper closure will depend on the material used in the fabric sheet and the zipper closure as well as on the conductive metal employed. The amount of conductive metal plated or coated on the fabric sheet and zipper closure will depend on the shielding properties desired. In general, it has been found that very thin layers of the metal coating or plating provide effective shielding over a broad range of frequencies. A preferred conductive metal is silver plated or coated on nylon in accordance with the Broadbent et al. disclosure.

The zipper closure may be attached to the fabric sheet edges by any effective means, such as sewing, welding or attaching with an adhesive. When attached by sewing or with an adhesive, the attachment should be made such that the metal plating or coating will provide uniform effectiveness of the shielding along the attachment line. The preferred method of attaching the zipper closure to the fabric sheet edge is by fusion or welding with an ultrasonic welder. This method assures uniform and complete contact between the zipper closure tape and the edge of the fabric sheet which can then be uniformly coated or plated with the conductive metal to provide uniform effectiveness in shielding.

As described above, the methods of making the wraparound tubular article of this invention may be performed in a number of alternative ways. A fiber or yarn which has been plated or coated with the conductive metal may be woven, braided, or warp knitted into the fabric sheet and then attached to a zipper closure which has been coated or plated with the conductive metal. Alternatively, the woven, braided, or warp knitted fabric sheet can be plated or coated with the conductive metal and attached to the zipper closure which has been also plated or coated with the conductive metal. In another alternative, the woven, braided, or warp knitted fabric sheet can be attached to the zipper closure and then the entire article plated or coated with the conductive metal. For economic reasons and for the most uniform final product, it is generally preferred to attach the zipper closure to the fabric sheet and then plate or coat the assembled article with the conductive metal.

Figure 1 illustrates a wraparound tubular article according to this invention. Fabric sheet 1 has zipper closure 2 attached to opposing edges of the fabric sheet along lines 3. The wraparound tubular article optionally contains a metalic ground strap or drainwire 4 which aids in connecting the wraparound tubular article to a grounding means.

The invention can be further understood by reference to the following examples. In these examples, the silver plating on the polyester and nylon yarns was basically applied by the processes disclosed in U.S. patent 3,877,965 to Broadbent et al.

Example 1

In this example, a first yarn was prepared from one end of a 525 denier multifill nylon yarn having 20% by weight silver plated thereon ("X-Static" yarn from Sauquoit Industries, Inc.), which was blended by simply a ply and twist with two ends of 300 denier texturized polyester yarn. The resulting twisted first yarn was 1200 denier. A second yarn was prepared from 50 denier multifill nylon yarn having 12% silver plated thereon ("X-Static" yarn) twisted with four ends of 300 denier texturized polyester. The resulting second yarn was 1250 denier. A fabric was woven using the first yarn in the warp and the second yarn in the filling. The fabric was woven in tubular form which when flattened into a tape was 1 3/4 inch wide. The fabric was woven to a density of 50 face ends per inch and 11 face picks per inch. A sample of this tubular article was tested in accordance with NEMA Pub. No. WC 41-1975, Part 3

with a 5 volt input on a sample 0.5 meters in length. (See also ELECTRI-ONICS, August 1984, pp. 35-39.) The shielding effectiveness is depicted in Figure 2 in terms of dB attenuation versus frequency.

Example 2

In this example, a first yarn was prepared as in Example 1 and a second yarn was prepared from spun nylon yarns as follows. A 300 denier spun nylon yarn was made using 4% by weight "X-Static" staple (nylon with 12% silver from Sauquoit Industries) and 96% nylon staple. Two ends of this 300 denier yarn was twisted with one end of 27 denier multifill nylon "X-Static" yarn (12% silver) to give a 627 denier yarn, two ends of which were twisted resulting in a yarn having 1254 denier and 8% by weight conductive fibers. A fabric was prepared as in Example 1 using the first yarn in the warp and the second yarn in the filling. This fabric was formed in a tubular article as in Example 1 and tested in accordance with Example 1. The shielding effectiveness is set forth in graphic form in Figure 3.

Example 3

In this example, a 500 denier multifil nylon yarn having 12% by weight silver plated thereon was twisted with two ends of a 300 denier texturized polyester producing a twisted first yarn having a total size of 1100 denier. A second yarn used in this invention is the same as the second yarn in Example 1. A fabric was woven in accordance with Example 1 using the first yarn in the warp and the second yarn in the fill. The same tubular article was

formed and tested in accordance with Example 1. The shielding effectiveness is set forth in graphic form in Figure 4.

Example 4

First and second yarns were prepared as in Example 3 and woven into a fabric as in Example 3 except that in the warp two stripes were inserted using a multifil nylon yarn of 1130 denier. The nylon yarn was made from one end of 500 denier multifil nylon plated with 12% by weight silver and three ends of 210 denier nylon multifilament which produced a nylon yarn having a total size of 1130 denier. Each stripe was 3/16 inch wide with 3/8 inch between the stripes of nylon. A sample of this tubular article was tested in accordance with Example 1 and the shielding effectiveness is set forth in Figure 5.

Example 5

Example 4 was repeated except that a nylon zipper plated with silver was ultrasonically bonded to the stripes of nylon yarn and the tubular article split under the center of the zipper to form a wraparound article. This sample was tested as in Example 4 and the shielding effectiveness is set forth in Figure 6.

Example 6

A wraparound tubular shield was made from a nylon fabric having 2000 denier multifilament warp yarn and 8 mil monofilament weft yarn. The zipper was a size 6 chain, 3/4

inch overall width, all nylon zipper available from American Robbin. The entire fabric sheet and zipper were separately plated with silver using the Broadbent et al. method to 11% by weight silver based on the weight of the finished plated article. The plated zipper was ultrasonically welded to the plated fabric. The wraparound shielding closure was then placed around a 2.5 inch flat 50-conductor ribbon cable and a 3-meter length of the wraparound shield was tested in accordance with I.A.W. MIL-STD-285 using the ribbon cable as receiver. The shielding effectiveness is shown in graphic form in Figure 7.

What is claimed is:

1. A fabric for electrical shielding which comprises a fabric which is woven, braided or warp knitted from a yarn which comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprises between about 15% and about 80% by weight of the fabric.

2. A fabric according to claim 1 wherein the conductive fibers comprise non-conductive fibers plated or coated with metal.

3. A fabric according to claim 2 wherein the conductive fibers comprise between about 15% and about 70% by weight of the fabric.

4. A fabric according to claim 3 wherein the conductive fibers comprise between about 20% and about 60% by weight of the fabric.

5. A fabric according to claim 2 wherein the fabric comprises a woven fabric comprising:

warp yarns in which the conductive fibers comprise between about 20% and about 80% by weight of the yarn; and

filling yarns in which the conductive fibers comprise between about 1% and about 20% by weight of the yarn.

6. A fabric according to claim 5 wherein the yarns comprise nylon or polyester.

7. A fabric according to claim 6 wherein the conductive yarns comprise nylon plated with silver.

8. A fabric according to claim 6 wherein the warp yarns comprise between about 30% and about 70% conductive fibers by weight.

9. A fabric according to claim 7 wherein the warp yarns comprise between about 30% and about 70% conductive fibers by weight.

10. An article for electrical shielding wherein the article is formed at least in part from a fabric which comprises woven, braided or warp knitted yarn which comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprise between about 15% and about 80% by weight of the fabric.

11. An article according to claim 10 wherein the fabric comprises a woven fabric comprising:

warp yarns in which the conductive fibers comprise between about 20% and about 80% by weight of the yarn; and

filling yarns in which the conductive fibers comprise between about 1% and about 20% by weight of the yarn.

12. An article according to claim 11 which is a tubular article.

13. An article according to claim 12 wherein the tubular article is a wraparound article.

14. A wraparound tubular article for enclosing and electrically shielding electrical conductors and cables comprising a nonconductive woven, braided, or warp knitted fabric sheet having two opposing edges and a nonconductive zipper closure attached to said opposing edges and adapted for holding the fabric sheet in a tubular configuration around an electrical conductor or cable wherein the woven fabric and the zipper closure are coated or plated with a conductive metal to thereby provide electrical shielding which is of substantially uniform effectiveness around the circumference of the wraparound tubular article when the zipper closure is closed.

15. The article according to Claim 14 wherein the fabric sheet is woven.

16. The article according to Claim 15 whrein the warp yarns are multifilament and the fill is monofilament.

17. The article according to Claim 14 wherein the fabric sheet is braided.

18. The article according to Claim 14 wherein the fabric sheet is warp knitted.

19. The article according to Claim 15 wherein the woven fabric is nylon.

20. The article according to Claim 19 wherein the fabric sheet and zipper closure are coated or plated with silver.

21. An assembly comprising a substrate and a fabric in shielding relationship therewith wherein the fabric is woven, braided or warp knitted from yarns which comprise conductive and non-comprises conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprises between about 15% and about 80% by weight of the fabric.

22. A method of making fabric for electrical shielding which comprises weaving, braiding or warp knitting yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the conductive fibers comprises between about 15% and about 80% by weight of the fabric.

23. A method of electrically shielding a substrate which comprises placing in shielding relationship with the substrate a fabric which is woven, braided or warp knitted from yarns which comprise conductive fibers and non-conductive fibers wherein the conductive fibers comprise fibers of carbon, graphite or conductive polymer or comprise non-conductive fibers which are plated, coated or impregnated with a conductive material and wherein the con-

ductive fibers comprises between about 15% and about 80% by weight of the fabric.

24. A method of making a wraparound tubular article for enclosing and electrically shielding electrical conductors and cables comprising plating or coating a woven, braided, or warp knitted fabric sheet with a conductive metal and attaching to the edges of the fabric sheet a zipper closure which has been coated or plated with a conductive metal.

25. A method of making a wraparound tubular article for enclosing and electrically shielding electrical conductors and cables comprising attaching a zipper closure to a woven, braided, or warp knitted fabric sheet and coating or plating the fabric sheet/zipper closure assembly with a conductive metal.

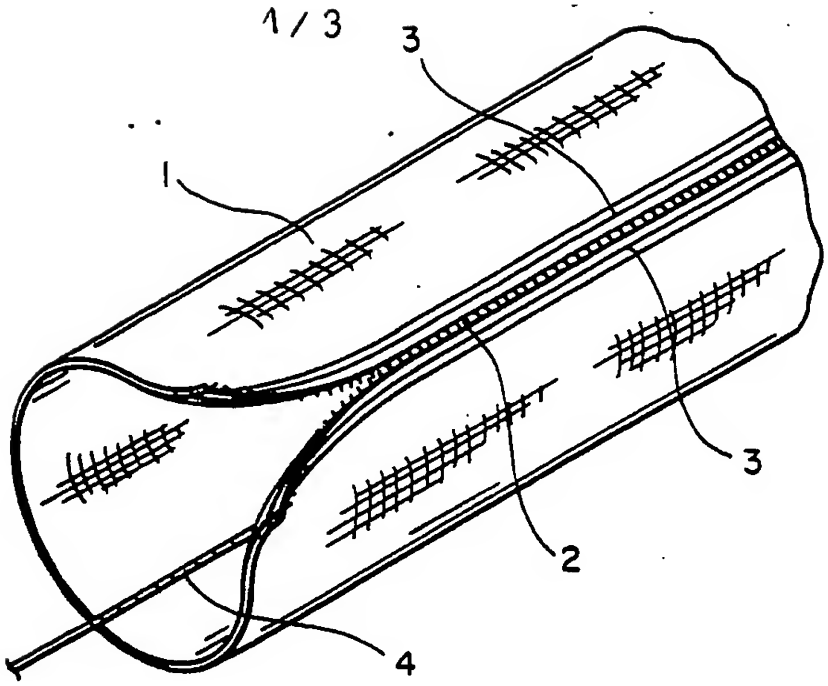

3
1
3
2
4

FIG_1

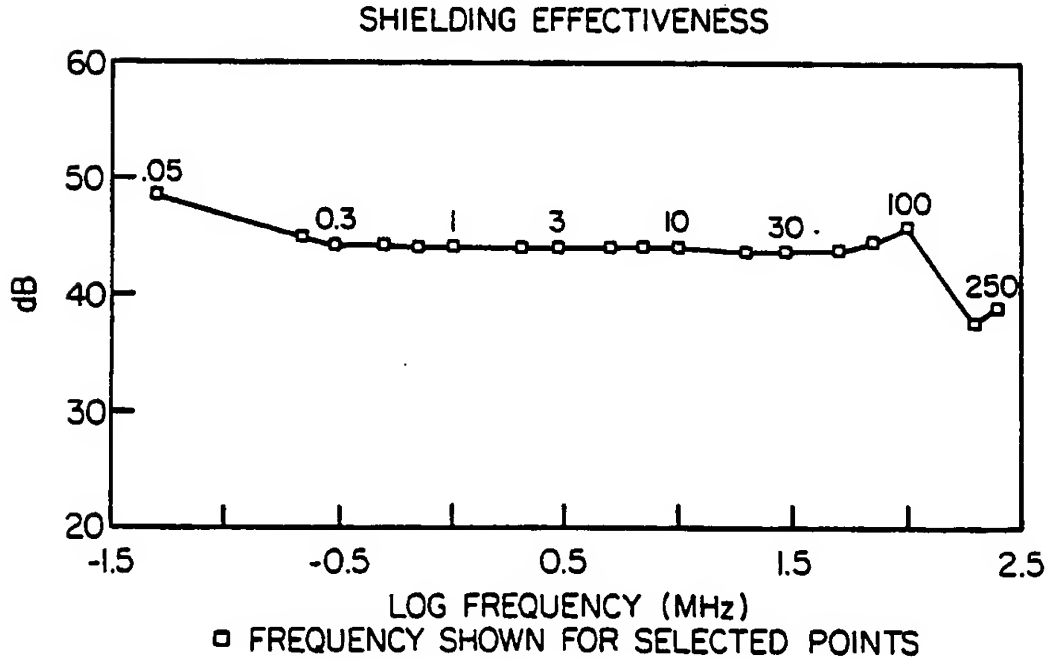

SHIELDING EFFECTIVENESS
60
50
40
30
20
dB
.05
0.3
1
3
10
30
100
250
-1.5
-0.5
0.5
1.5
2.5
LOG FREQUENCY (MHz)
□ FREQUENCY SHOWN FOR SELECTED POINTS

FIG_2

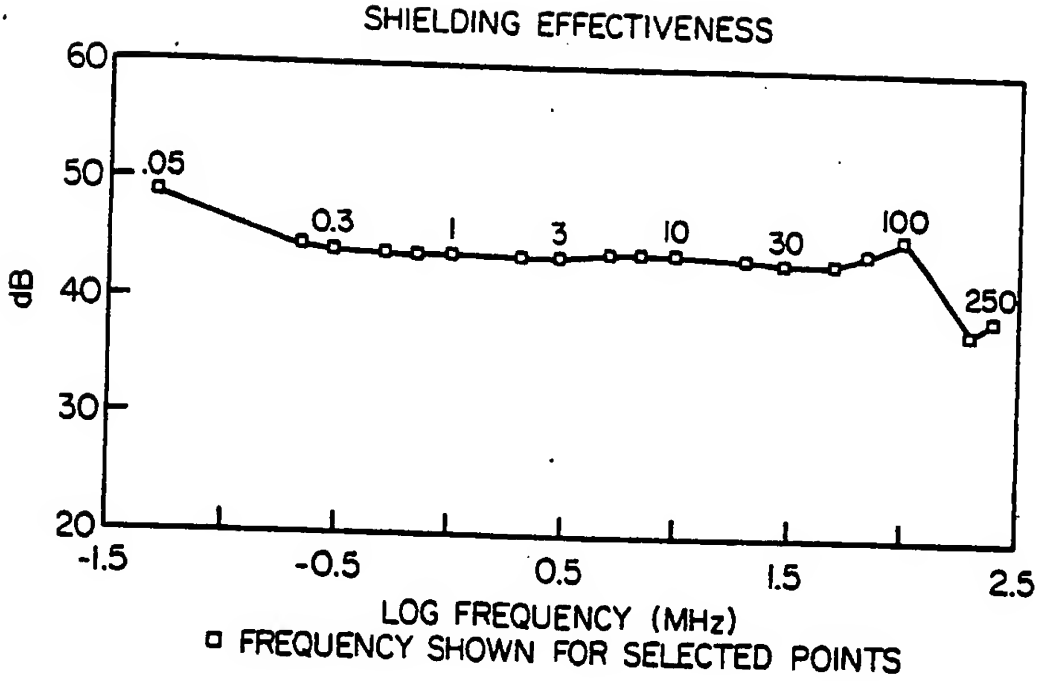

SHIELDING EFFECTIVENESS
60
50
40
30
20
dB
.05
0.3
1
3
10
30
100
250
-1.5
-0.5
0.5
1.5
2.5
LOG FREQUENCY (MHz)
□ FREQUENCY SHOWN FOR SELECTED POINTS

FIG_3

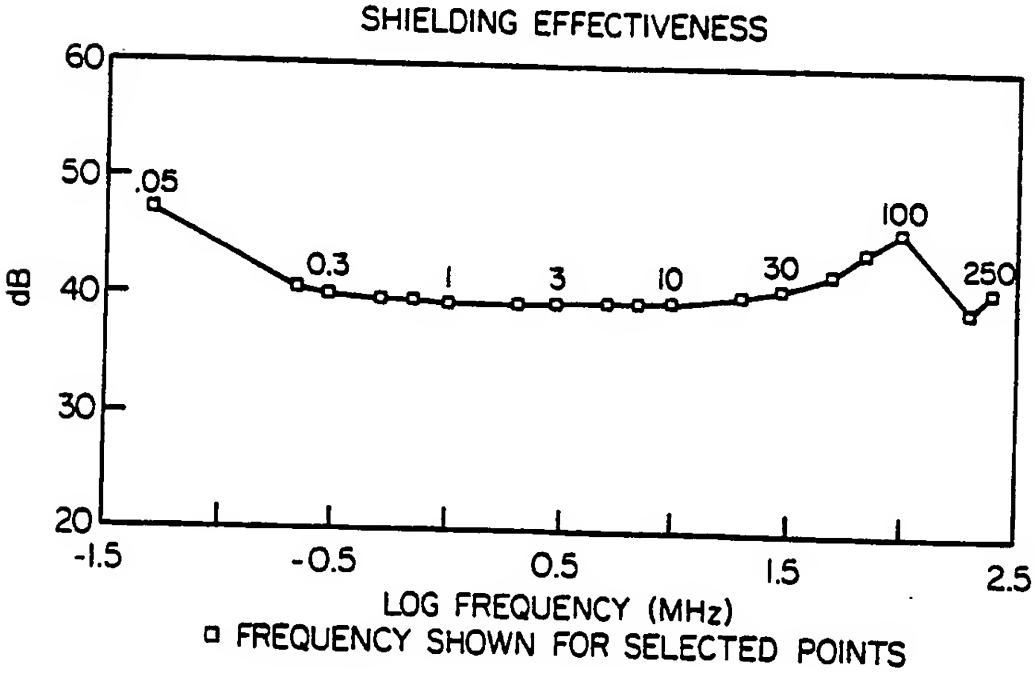

SHIELDING EFFECTIVENESS
60
50
40
30
20
dB
.05
0.3
1
3
10
30
100
250
-1.5
-0.5
0.5
1.5
2.5
LOG FREQUENCY (MHz)
□ FREQUENCY SHOWN FOR SELECTED POINTS

FIG_4

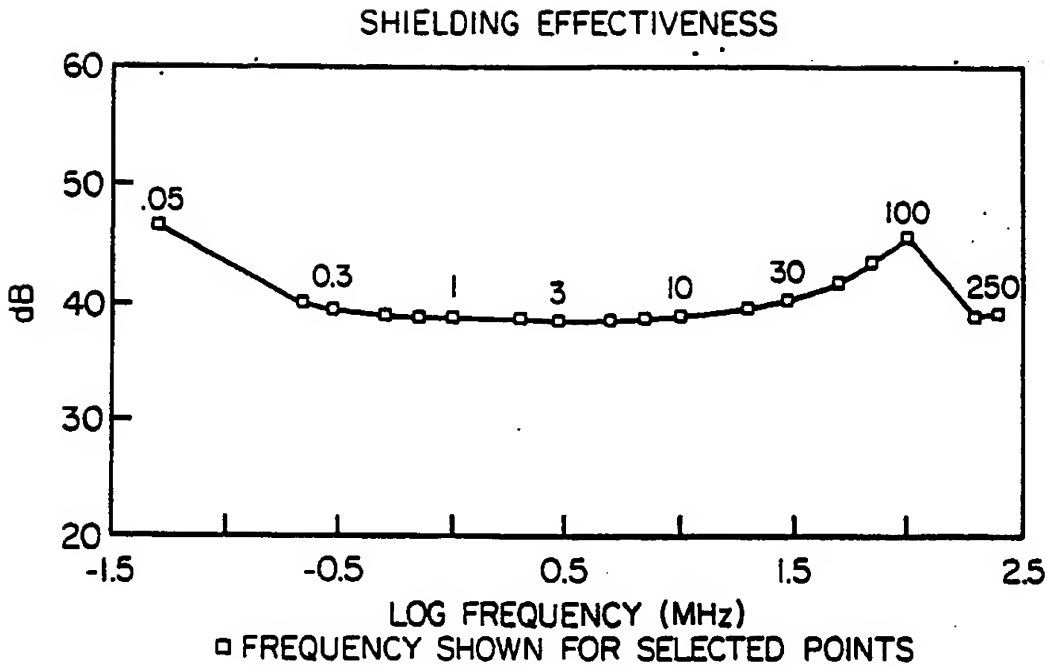

SHIELDING EFFECTIVENESS
60
50
40
30
20
dB
.05
0.3
1
3
10
30
100
250
-1.5
-0.5
0.5
1.5
2.5
LOG FREQUENCY (MHz)
□ FREQUENCY SHOWN FOR SELECTED POINTS

FIG_5

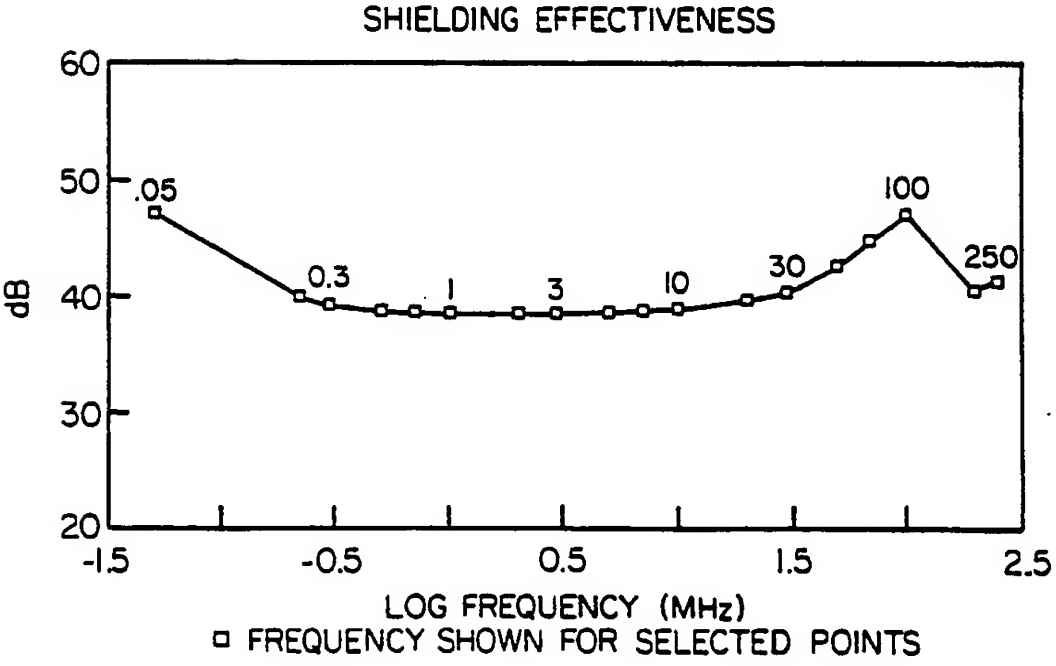

SHIELDING EFFECTIVENESS
60
50
40
30
20
dB
.05
0.3
1
3
10
30
100
250
-1.5
-0.5
0.5
1.5
2.5
LOG FREQUENCY (MHz)
□ FREQUENCY SHOWN FOR SELECTED POINTS

FIG_6

INTERNATIONAL SEARCH REPORT

International Application No PCT/US85/02245

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC [4]

H01B 7/34; H05K 9/00; D03D 15/00; D04B1/00; D04C1/00; DO4H 1/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
US	174/35MS, 36,117m, DIG.11 139/425R 428/229,408,922 87/1,8 and 9 66/169R, 170, 202, 232

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A 2,585,054 (STACHURA) 12 February 1952	
A	US, A 3,089,915 (PLUMMER) 14 May 1963	
A	US, A 3,195,395 (McCALLUM) 20 July 1965	
A	US, A 3,253,618 (COOK) 31 May 1966	
A	US, A 3,582,445 (OKUHASHI) 1 June 1971	
A	US, A 3,582,532 (PLUMMER) 1 June 1971	
A	US, A 3,733,213 (JACOB) 15 May 1973	
Y	US, A 3,877,965 (BROADBENT et al) 15 April 1975	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
January 24, 1986	25 MAR 1986
International Searching Authority [1]	**Signature of Authorized Officer** [10]
RO/US	Morris Nimmo

Form PCT/ISA/210 (second sheet) (October 1981)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
A	US, A 3,946,143 (MCLOUGHLIN) 23 March 1976	
A	US, A 3,986,530 (MAEKAWA) 19 October 1976	
A	US, A 4,016,356 (MCLOUGHLIN) 5 April 1977	
A	US, A 4,042,737 (FORSGREN et al) 16 August 1977	
A	US, A 4,232,082 (NORITAKE) 4 November 1980	
A	US, A 4,247,596 (YEE) 27 January 1981	
A	US, A 4,281,211 (TATUM et al) 28 July 1981	
A	US, A 4,296,855 (BLALOCK) 27 October 1981	
A	US, A 4,362,779 (ARSAC) 7 December 1982	
A	US, A 4,375,009 (FEARNSIDE et al) 22 February 1983	
A	US, A 4,409,427 (PLUMMER III) 11 October 1983	
A	US, A 4,471,015 (EBNETH et al) 11 September 1984	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers: 1-13 and 21-23. Response filed 4 March 1986 to the invitation to pay additional fees mailed 14 February 1986 was not timely received. Refer to 37CFR1.8 (xi).

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.